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INTERSTELLAR HYDROGEN AND COSMIC BACKGROUND RADIATION

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Abstract

It is shown that a collection of photons with nearly the same frequency exhibits a "condensation" type of phenomenon corresponding to a peak intensity. The observed cosmic background radiation can be explained from this standpoint in terms of the radiation due to fluctuations in interstellar Hydrogen.

In a previous communication[1] it was suggested that the origin of the Cosmic Background Radiation is the random motion of interstellar Hydrogen. We will now deduce the same result from a completely different point of view. We start with the formula for the average occupation number for photons of momentum $\vec{k}$ for all polarizations[2]:

$$\langle n_{\vec{k}} \rangle = \frac{2}{e^{\beta \hbar \omega} - 1} \tag{1}$$

Let us specialize to a scenario in which all the photons have nearly the same energy so that we can write,

$$\langle n_{\vec{k}} \rangle = \langle n_{\vec{k}'} \rangle \delta(k - k'), \tag{2}$$

where $\langle n_{\vec{k}'} \rangle$ is given by (1), and $k \equiv |\vec{k}|$. The total number of photons N, in the volume V being considered, can be obtained in the usual way,

$$N = \frac{V[k]}{(2\pi)^3} \int_o^\infty dk 4\pi k^2 \langle n_k \rangle \tag{3}$$

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where V is large. Inserting (2) in (3) we get,

$$N = \frac{2V}{(2\pi)^3} 4\pi k'^2 [\epsilon^\theta - 1]^{-1}[k], \theta \equiv \beta\hbar\omega, \tag{4}$$

In the above, $[k] \equiv [L^{-1}]$ is a dimensionality constant, introduced to compensate the loss of a factor k in the integral (3), owing to the δ-function in (2): That is, a volume integral in $\vec{k}$ space is reduced to a surface integral on the sphere $|\vec{k}| = k'$, due to our constraint that all photons have nearly the same energy.
We observe that, $\theta = \hbar\omega/KT \approx 1$, since by (2), the photons have nearly the same energy $\hbar\omega$. We also introduce,

$$\upsilon = \frac{V}{N}, \lambda = \frac{2\pi c}{\omega} = \frac{2\pi}{k} \quad \text{and} \quad z = \frac{\lambda^3}{\upsilon} \tag{5}$$

λ being the wave length of the radiation. We now have from (4), using (5),

$$(e - 1) = \frac{\upsilon k'^2}{\pi^2}[k] = \frac{8\pi}{k'z}[k]$$

Using (5) we get:

$$z = \frac{8\pi}{k'(e-1)} = \frac{4\lambda}{(e-1)}[k] \tag{6}$$

From (6) we conclude that, when

$$\lambda = \frac{e-1}{4} = 0.4[L] \tag{7}$$

then,

$$z \approx 1 \tag{8}$$

or conversely.
Though equation (7) is quite general, as it stands, we have to assign suitable units to it depending on the particular physical situation: We must get an additional input, in the order of magnitude sense, from the system under consideration to fix the units.
Let us now consider the case of radiations due to fluctuations of the cold interstellar Hydrogen as considered from an alternative view point in ref.[1]. In this case it is infact known that $\frac{1}{\upsilon} \sim 1$ molecule per c.c.[2, 3]. On the

other hand, the energy range for these cold molecules is small, so that the above considerations apply. So from (7), owing to the fact that $\upsilon^{1/3} \sim \lambda cm.$, it follows that,

$$\lambda = 0.4cm. \tag{9}$$

Remembering that from (5), λ is the wave length and υ is the average volume per photon, the condition (8) implies that all the photons are very densely packed as in the case of Bose condensation. This means that from (9), we conclude that at the wave length $0.4cm$, in the micro-wave region, the radiation has a peak intensity. It is remarkable that the cosmic background radiation has the maximum intensity exactly at the wave length given by (9)[4]. So, even without the Big Bang event it is possible to receive the observed cosmic background radiation due to fluctuations in interstellar Hydrogen (cf.ref.[3] and[5] for Hoyle and Wickramasinghe's attempt to explain the background radiation in terms of Helium synthesis, without invoking the Big Bang.)
The same conslusion can be obtained from yet another argument also[6]. Interestingly, El Naschie has studied the Cosmic Background Radiation from the point of view of fractal quantum space time[7, 8].

References

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